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ORIGINAL ARTICLE

Modelling transfer of *Salmonella* Typhimurium DT104 during simulation of grinding of pork

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Why Robustness?

Can the model predict /describe transfer of different pathogens during grinding of different food matrices using different equipment at different temperatures?

Aim

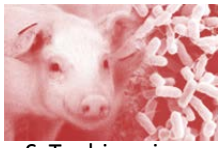
To investigate the robustnes of a transfer model by three different criteria

1) ASZ

2) QMRA approach

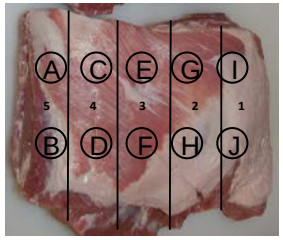
3) TTP%

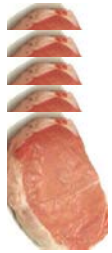
17 + 3 grinding trials



S. Typhimurium
DT104

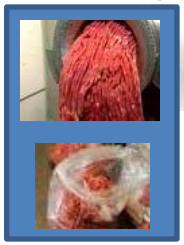
37° C ,overnight +
5° C, 1-3 days
Ca.10^9
Salmonella / g





Matrix

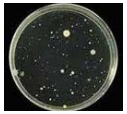
Salmonella



Up to100
slices

Distribution of
Salmonella

37°C, 24h



22°C, 3d

- Analysis performed
- Build up the model
- Validation

Transfer Modelling

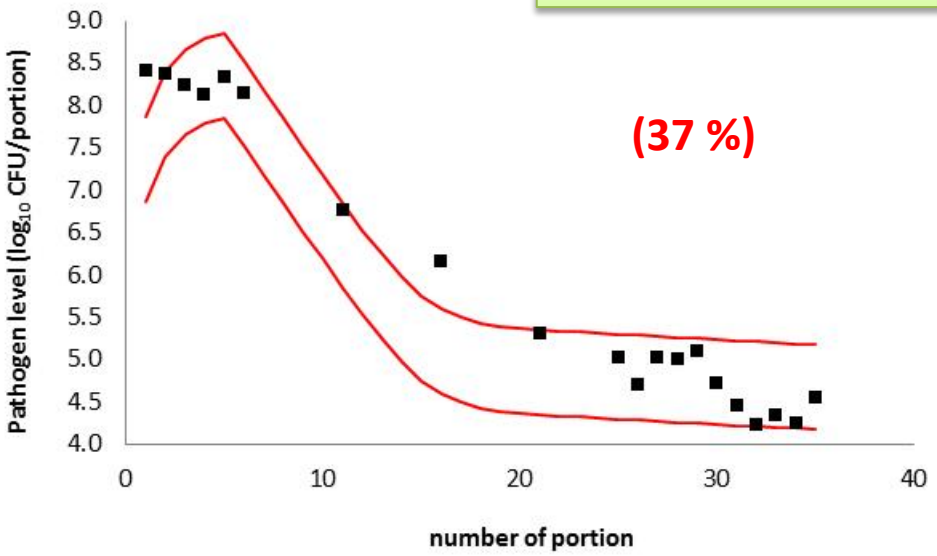
Different grinding conditions

- Type of grinder
  - 2 different degrees of roughness in the surfaces
- Type of meat matrice
  - Pork
  - Beef
- Size of pieces of meat
  - 50 g
  - 157 – 324 g
- Number of pieces of meat
  - 10 - 100
- Pathogen
  - Single strain of *S.* Enteritidis 54
  - Cocktail of *S.* Enteritidis
  - *S.* Typhimurium DT104
  - *L. monocytogenes*
- Room temperature
  - 4 °C
  - 19-27 °C
- Sharpness of grinder knife

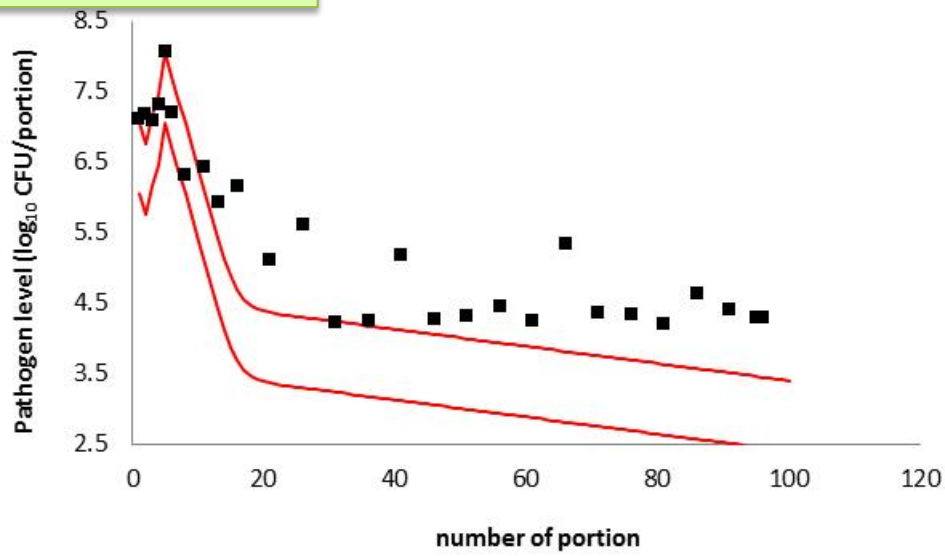
Robustness assessed by Acceptable simulation Zone

- Applying the parameters suggested by Møller et al. in 2012 to simulate the cross contamination events observed in the remaining nineteen trials.
- In this study, ASZ of ± 0.5 log_{10}CFU per portion.

70 % of observations inside the ASZ



(37 %)



Robustness assessed by a QMRA approach

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Risk assessment of *Salmonella* in Danish meatballs produced in the catering sector

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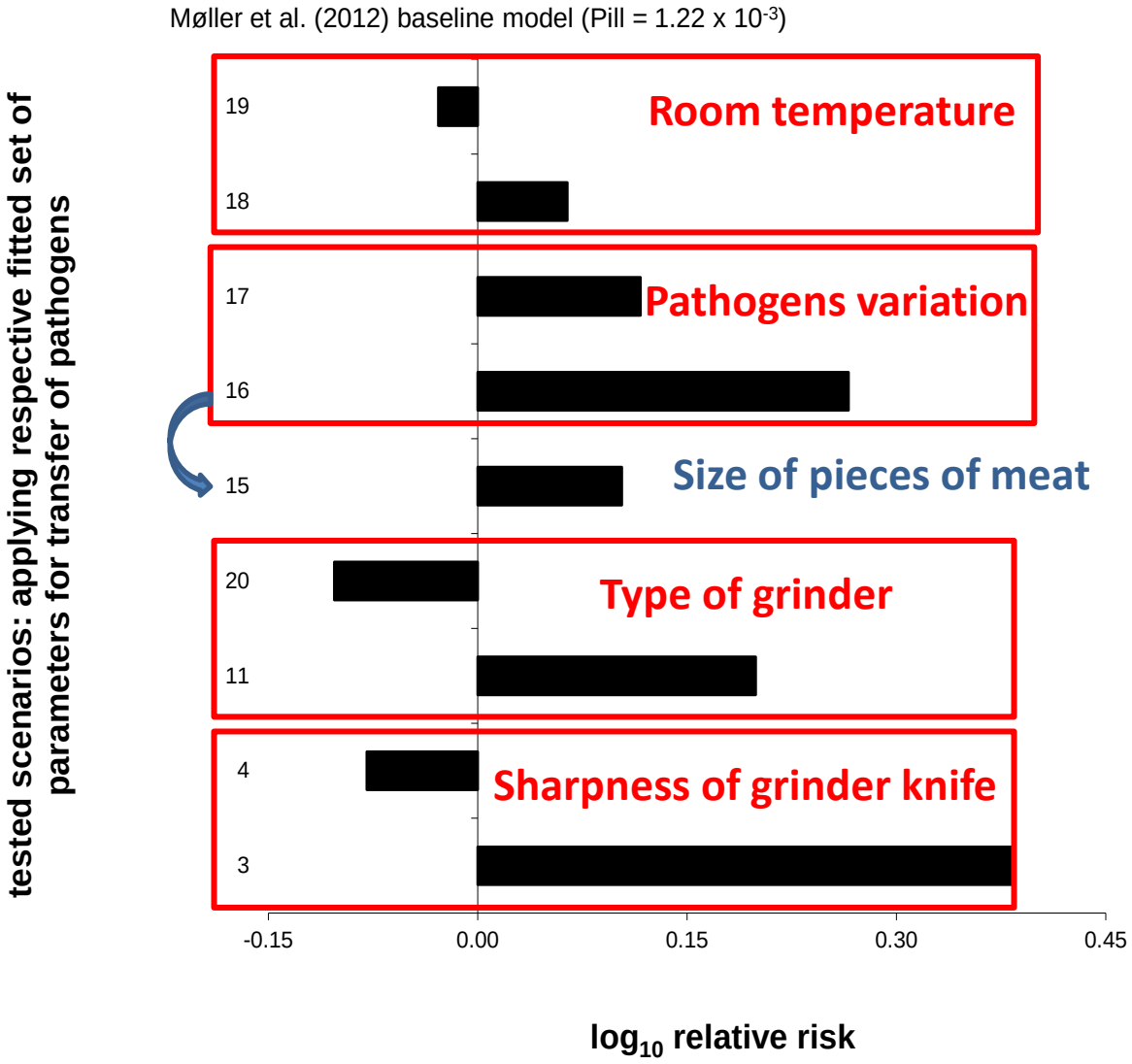
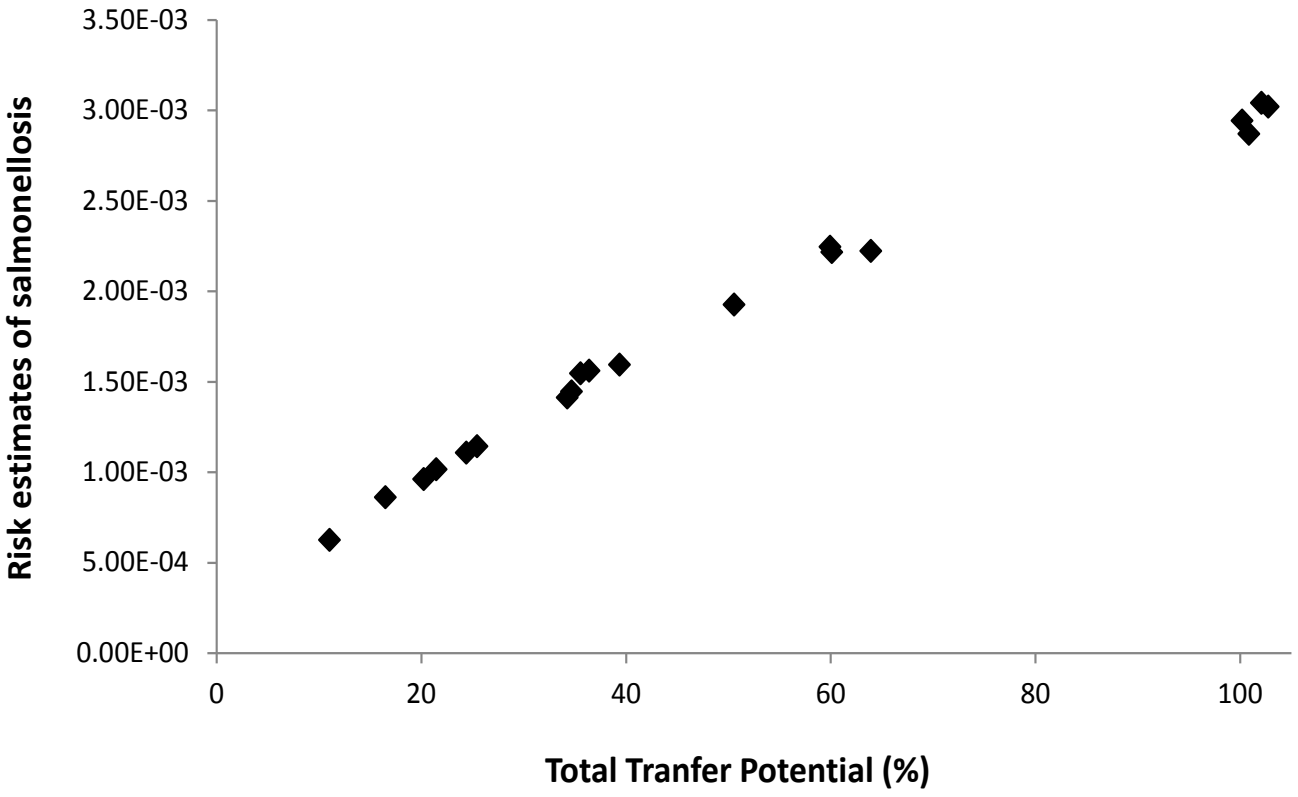
Relative risk from different grinding parameters comparing to the baseline of of Møller et al 2012.



Robustness assessed by Total Transfer Potential (TTP %)

$$TTP = \frac{\sum_{i=1}^{\infty} M_i}{S_1} = \left(1 - a_2\left(1 - a_1 - \frac{b_2}{c_3 + b_2(1 - c_3)}\right)\right) \times 100\%$$



Correlation between all three approaches applied for model evaluation

> 1.1 log_{10}CFU > 2.1 x 10^{-3} > 60 %

Table 2. Summary of performance results (with extreme values in **bold**) obtained with three different approaches for evaluating performance of the model proposed by Møller et al. (2012)[1] describing the transfer of pathogens during meat grinding.

Trial	Parameter estimates from fitting					RMSE[b]	Size of ASZ[c] to include 100 % of the predictions (± CFU/portion of meat)	Absolute Risk[e] Estimates x 10^{-3}	TTP %[f]
	a_1	b_1	a_2	b_2	1-c_3				
1	0.0558	0.0544	0.4946	0.4175	1.0000	1.2038	**2.0**	**3.02**	**103**
2	0.0503	0.0454	0.1707	0.3522	1.0000	1.1536	**2.0**	**2.87**	**101**
3	0.0335	0.0569	0.0612	0.1485	1.0000	1.0754	**2.0**	**2.94**	**100**
4	0.0041	0.0471	0.8778	0.0570	0.4641	1.1018	0.8	1.01	21
5	0.0118	0.0652	0.7787	0.0927	0.5058	1.0760	**1.4**	1.56	36
6	0.0104	0.0677	0.8330	0.0588	0.3004	1.1079	**1.2**	1.10	24
7	0.0092	0.1472	0.8697	0.0261	0.1459	1.1879	1.1	0.86	16
8	0.0107	0.0265	0.9388	0.0253	0.4024	1.1508	**1.2**	0.62	11
9	0.0167	0.0061	0.5386	0.0579	0.8083	1.2202	**2.0**	**2.21**	60
10	0.4227	0.0052	0.4250	0.2715	0.5905	2.0930	0.7	1.94	**96**
11	0.0047	0.0358	0.6549	0.1251	0.5479	1.1744	1.1	1.92	51
12	0.0799	0.3165	0.2611	1.0000	0.0000	1.4371	**1.4**	**3.04**	**102**
13	0.0293	0.2433	0.8785	0.1648	0.3284	1.1196	**1.2**	1.44	35
14	0.0054	0.1127	0.5721	0.1653	0.6541	1.1802	**1.5**	**2.22**	**64**
15	0.0054	0.1584	0.7369	0.0484	0.6276	1.1909	1.1	1.54	36
16	0.0130	0.1134	0.5289	0.1304	0.4963	1.1451	1.1	**2.24**	60
17	0.0142	0.1022	0.7746	0.1767	0.1588	1.2773	**2.2**	1.59	39
18[a]	0.0008	0.0655	0.7924	0.1331	0.2475	1.2029	0.6	1.41	34
19[a]	0.0020	0.0809	0.8166	0.0555	0.3692	1.1345	0.6	1.14	25
20[a]	0.0010	0.0275	0.8909	0.0558	0.4887	1.1378	NA[d]	0.96	20

[a] data published by Møller et al. (2012).
[b] Root Mean Sum of squared Errors.
[c] ASZ – Acceptable Simulation Zone, proposed by Oscar in 2005[2] and tested by Møller et al. in 2013[3].
[d] NA – Not Applicable, because the parameters applied to access the ASZ were obtained by the fitting of trial 20.
[e] risk estimates from scenarios testing different sets of transfer parameters (Table 2), and using the QMRA of *Salmonella* in meatball processing model (Møller et al., 2015[4]) at low concentration and prevalence of the pathogen.
[f] Calculated with the equation derived from Møller et al. (2012)[1]. It indicates the percentage (%) of CFU of *Salmonella*, from the contaminated grinded pieces that ends up in the total minced meat, assuming that the grinding process will continue forever.

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Final Considerations

- Applying the Acceptable Simulation Zone the cross contamination parameters suggested by Møller et al. (2012) are not able to describe all nineteen observed trials.
- The observed values had its cross contamination event well described when fitted to the model structure proposed by Møller et al. (2012).
- Parameter estimates obtained by fitting observed trials performed at different conditions, such as size of processed pieces of meat and number of processed slices, may not be applied to describe cross contamination of unlike processing.
- The QMRA, and the Total Transfer Potential, revealed that the risk may be reduced when the grinding is performed in a grinder made of stainless steel, using well-sharpened knifes, and at room temperatures lower than 4°C.

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